Section 4
Tour of the Cell
Note Sheets

BIOLOGY 6.0

CHAPTER 4 – A TOUR OF THE CELL

READING: P. 51 CELLS ON THE MOVE

What type of human cells move? SPERM, WBC, CANCER

What word did Leeuvenhoek call bacteria he saw moving under the microscope? ANIMACULE

Do all cells have structures that move about? YES

Why do they use micrographs and drawings in textbooks? SHOW STRUCTURE AS BIOLOGISTS SEES IT DRAWING HELPS YOU UNDERSTAND THE MICROGRAPH BY EMPHASIZING SPECIFIC DETAILS

On what does this chapter focus? CELL STRUCTURE + FUNCTIONS

INTRODUCTION TO THE CELL

4.1 MICROSCOPES REVEAL THE WORLD OF THE CELL

A. The first microscopes were LIGHT microscope developed in the 17th the century

1. Visible light is passed through the SPECIMEN and GLASS lenses BEND the light to magnify the image and project it into the EYE, onto a SCREEN (or) on FILM
2. MAGNIFICATION - increase in the APPARENT size of an object
   a. P. 52, Fig. 4.1B – LM 230X tells us the light microscope was used and the image is 230 x the actual size
   b. Use METRIC units to describe the length, width, etc.
   c. The light microscope can effectively magnify only about 1000 x
3. RESOLUTION - measurement of CLARITY of an image
   a. The ability of optical instruments to show two CLOSE objects as separate (as 2 STARS)
   b. There is a LIMIT to resolution as the human eye can't resolve details finer than 0.1 mm and the light microscope can resolve as small as .2 µm (MICROMETER) (smallest bacterium) (1/MILLIONTH OF METER)

B. In 1665, Robert HOOKE discovered cells with the light microscope and until the mid-20th century, that's all there was

C. Its use lead to the CELL THEORY in the mid-1800s

1. All living things are composed of CELLS (SCHLEIDEN + SCHWANN)
2. All cells come from OTHER cells (VIRCHOW)

D. In the 1950s, the ELECTRON microscope (EM) began to be used

1. It uses a beam of ELECTRONS instead of light
2. It provides greater RESOLUTION than the light microscope

E. The logistics of carrying out cell functions set limits on cell SIZE

1. Cells must be able to house enough DNA, protein molecules and INTERNAL structures to survive and REPRODUCE at a minimum

2. Maximally, size is influenced by its requirements for enough SURFACE AREA to obtain adequate nutrients and oxygen from the environment and to dispose of WASTES, limited also by DISTANCE materials must DIFFUSE into the cell

3. Large cells have more surface area but less RELATIVE surface area to VOLUME than small cells of the same SHAPE (P. 54, Fig. 4.2B)

   a. One large cube – 30 µm/side = (6 x 30 x 30) = 5400 μm^2

   b. 27 small cubes – 10 µm/side = 27 x 10 x 10) = 6300 μm^2

   c. Volume is still the same at 27,000 μm^3

4. So large cells have much SMALLER surface area relative to its volume

5. Need surface area large enough to SERVICE the cell's volume

4.3 PROKARYOTIC CELLS ARE STRUCTURALLY SIMPLER THAN EUKARYOTIC CELLS

A. PROKARYOTES - bacteria and archaea

B. EUKARYOTES -protists, fungi, plants and animals

C. All with several basic features in common

1. PLASMA MEMBRANE - boundary
2. CHROMOSOME/S - carry genes of DNA
3. RIBOSOMES - where proteins are made
4. CYTOPLASM

D. Eukaryotic – only membrane enclosed NUCLEUS and membrane enclosed ORGANELLES

E. Prokaryotes (Pro - BEFORE, karyon - KERNEL)

1. 1-10 µm (about 1/10 that of eukaryotic)

2. Lacks NUCLEAR membrane but chromosomes are in a region called the NUCLEOID

3. Ribosomes are SMALLER and differ somewhat from eukaryotic ribosomes

   a. These molecular differences are the basis of the action of some ANTIBIOTICS

   b. They TARGET prokaryotic ribosomes but not eukaryotic

4. Outside THE membrane they have fairly rigid cell WALL to protect and to maintain SHAPE

E. Nonmembranous structures

1. CYTOSKELETON - protein tubes called MICROTUBULES and other protein filaments (MICROFILAMENTS) and ribosomes

2. Ribosomes, the sites of PROTEIN SYNTHESIS, are found throughout the cytoplasm or are ATTACHED to the endoplasmic reticulum

4.5 THE STRUCTURE OF MEMBRANES CORRELATES WITH THEIR FUNCTIONS

A. Controls the traffic of material INTO and OUT OF the cell

B. PHOSPHOLIPIDS are the main components with two distinct regions

1. Negatively charged, HYDROPHILIC phosphate groups (HEAD)

2. Two nonpolar, HYDROPHOBIC, fatty acid TAILS (P. 58, Fig. 4.5A)

3. Forms a phospholipids BILAYER as the hydrophilic head face OUT to interact with the watery environment and the HYDROPHOBIC tails point INWARD, away from water

4. Embedded in the lipid bilayer or attached to the surface are diverse proteins

a. Interior portions of the membrane proteins are HYDROPHOBIC

b. Exterior parts are HYDROPHILIC

5. PERMEABILITY to various substances relates to the proteins of the lipid bilayer

a. Nonpolar (OXYGEN and CO_2) easily pass through

b. Other functions of the membrane depend on the kinds of proteins associated with the membrane – CHANNELS for ions and other hydrophilic molecules

CELL STRUCTURES INVOLVED IN MANUFACTURING AND BREAKDOWN

4.6 THE NUCLEUS IS THE CELL'S GENETIC CONTROL CENTER

A. Contains most of the cell's DNA

B. Controls the cell's activity by directing PROTEIN SYNTHESIS

C. Eukaryotic CHROMOSOMES are made of CHROMATIN (DNA and proteins)

D. DNA is COPIED as the cell readies itself to divide and chromosomes COIL up, becoming VISIBLE as chromosomes

E. Enclosing them is the nuclear ENVELOPE, a double layer with protein-lined PORES controlling the flow in and out, connects to the ER

F. NUCLEOLUS - the site where RIBOSOMAL RNA is synthesized and added to proteins to from ribosomes that go to the cytoplasm

G. The nucleolus also makes MESSENGER RNA from DNA that moves to the cytoplasm to the ribosomes to assemble the amino acids into proteins

b. In the liver, enzymes in the ER process DRUGS and other potentially harmful substances

1) Undesirable complication when the liver cells respond, the amount of enzyme INCREASES and this increases the rate of DETOXIFICATION
2) This increases the body's TOLERANCE to the drug so need MORE for same effect

c. Helps store CALCIUM ions

1) Pumped into INTERIOR of the ER
2) When nerve signals stimulate muscles, Ca+ RUSHES INTO the cytoplasmic fluid and triggers CONTRACTION

C. Rough Endoplasmic Reticulum

1. One function is to make more MEMBRANE

2. Bound ribosomes produce proteins that will be INSERTED into the ER membrane or SECRETED (as insulin)

3. P. 60, Fig. 4.9B – synthesis, modification and packing of secretory proteins

a. Polypeptides go into the ER cavity through a PORE

b. Short SUGAR chain is attached - GLYCOPROTEIN

c. Packs the molecules into a TRANSPORT vesicle

d. Vesicle BUDS OFF the ER membrane

e. Travels to the GOLGI for further processing

4.10 THE GOLGI APPARATUS FINISHES, SORTS AND SHAPES CELL PRODUCTS (P. 61, Fig. 4.10)

A. The ER transport vesicle goes to the Golgi

B. The Golgi consists of FLATTENED SACS stacked on top of each other but not INTERCONNECTED like the ER

C. The number of Golgi per cell correlates with how ACTIVE the cell is in secreting proteins

D. Functions

1. Serves as a molecular WAREHOUSE and FINISHING factory as it receives and modifies proteins manufactured in the ER

2. One side of the Golgi stack serves as a RECEIVING dock – vesicles from the ER JOIN

3. The other side SHIPS - gives rise to new vesicles that BUD OFF and travel to the other sites
4. Products are MODIFIED between receiving and shipping

a. The CARBOHYDRATE portion of the glycoprotein, for example, are added

b. The molecular ID TAGS (phosphate group) added to sort for different DESTINATIONS

C. Peroxisome

1. Not part of the endomembrane system but is involved in various METABOLIC functions
2. Break down of FATTY ACIDS and DETOXIFICATION of ALCOHOL, etc.
3. Contain CATALYASE to break down peroxide

4.14 MITOCHONDRIA HARVEST CHEMICAL ENERGY FROM FOOD

A. Organisms that carry out cell respiration, converting chemical energy from food (SUGARS) to the chemical energy of ATP

B. Enclosed by 2 membranes (bilayers) with a collection of EMBEDDED proteins

1. Two internal compartments

a. Intermembrane space – between the OUTER membrane and the INNER

b. Mitochondrial MATRIX

1) Enclosed by the INNER membrane
2) Contains mitochondrial DNA, RIBOSOMES and enzymes for CELL RESPIRATION

c. The inner membrane is highly FOLDED (P.63, Fig. 4.14)

1) Has proteins that make ATP embedded in it
2) The folds, called CRISTAE, increase the surface area for maximum energy production

4.15 CHLOROPLASTS CONVERT COLAR ENERGY TO CHEMICAL ENERGY

A. PHOTOSYNTHESIS - conversion of SOLAR energy of the sun to CHEMICAL energy of sugar

B. CHLOROPLASTS (CHLORO - green) – photosynthesizing organelles

C. Internal membranes partition chloroplasts into compartments

1. Inner and outer membranes are separated by a thin INTERMEMBRANE space
2. This thick fluid-filled STROMA contains chloroplasts, DNA, ribosomes with many enzymes
3. A network of interconnected sacs, the THYLAKOIDS, are stacked into GRANA like poker chips
4. Grana are SOLAR powered packs where chlorophyll TRAPS solar energy

4.16 MITOCHONDRIA AND CHLOROPLASTS EVOLVED BY ENDOSYMBIOSIS

A. Both have CIRCULAR DNA molecules similar to chromosomes of PROKARYOTES

B. Ribosomes also are more SIMILAR to prokaryotes

C. They reproduce by a SPLITTING process like prokaryotes

c. Readily disassembled in REVERSE manner
d. Animal cells grow microtubules out of a microtubule-organizing center – the CENTROSOME
e. A pair of CENTRIOLES are in the centrosome (for cell DIVISION)
f. They shape and support the cell and act as TRACKS along which organelles equipped with MOTOR proteins can move (lysosomes "WALK" along the microtubules to reach a food vacuole)
g. They guide the movement of CHROMOSOMES when cell divide

4.18 CILIA AND FLAGELLA MOVE WHEN MICROTUBULES BEND (P. 66, Fig. 4.18 A, B)

A. Cilia (as in PARAMECIUM) and flagella (as in SPERM), locomotor appendages, protrude from certain cells

1. Cilia - SHORT, NUMEROUS wave-like motion

2. Flagella - LONG, whip-like, UNDULATING motion

B. Cilia also line the cells of the RESPIRATORY system in humans to sweep DEBRIS out of the lungs

C. They have common structure and mechanism of movement

1. Made of microtubules wrapped in an EXTENSION of the plasma membrane

2. Made of a RING of 9 microtubule DOUBLETS around a central pair called a 9-2 pattern
3. BASAL body - ANCHORING structure, similar in structure to centrioles

4.19 PROBLEMS WITH SPERM MOTILITY MAY BE ENVIRONMENTAL OR GENETIC

A. In the last 50 years, there seems to be a DECLINE in sperm quality in developed countries

1. Lower COUNTS
2. Higher number of MALFORMED sperm
3. Reduced MOTILITY

B. One hypothesis on this is linked to an increase in HORMONALLY active chemicals in the environment and in people's bodies

1. Chemicals called PHTHALATES interfere with sex hormones in rats

2. They are used in COSMETICS, DEODORANTS, in plastic packaging, medical tubing, children's TOYS
3. Men, with higher concentrations of break down produces of phthalates, had LOWER sperm count and motility

C. Other problems are clearly GENETIC as in immobile CILIA syndrome which causes recurrent INFECTIONS of the respiratory tract and immobile sperm

4.20 THE EXTRACELLULAR MATRIX OF ANIMAL CELLS FUNCTIONS IN SUPPORT MOVEMENT AND REGULATION

A. Most cells synthesize and secrete materials that are external to the plasma membrane and essential to many cell functions

2. SECONDARY wall

   a. Deposited in LAMINATED layers
   b. Strengthened with LIGNIN, a major component of WOOD and sticky polysaccharides that glue the cells together

C. Plant cells are not totally isolated from other cells – must have cell JUNCTIONS

1. PLASMODESMATA - channels between adjacent cells
2. Used for circulating and communication system – share water, NOURISHMENT and chemical messengers

FUNCTIONAL CATEGORIES OF CELL STRUCTURES

4.23 REVIEW: EUKARYOTIC CELL STRUCUTURES CAN BE GROUPS ON THE BASIS OF 4 BASIC FUNCTIONS (Table P. 69)

A. Manufacturing (synthesis and transport)

1. NUCLEUS – DNA synthesis, DNA synthesis
2. RIBOSOMES - polypeptides/proteins
3. ROUGH ER - synthesis of membrane lipids and proteins, form transport vesicles
4. SMOOTH ER - lipid synthesis, detoxification, Ca+ storage
5. GOLGI - modify and transport of macromolecules form lysosomes and transport vesicles

B. Breakdown – breakdown and recycle material that are harmful

1. LYSOSOMES - digest food, bacteria, damaged organelles
2. VACUOLES - digestion, storage, water balance
3. PEROXISOMES - diverse metabolic processes, breakdown peroxide

C. Energy Processing

1. MITOCHONDRIA - chemical energy of food to ATP
2. CHLOROPLASTS - conversion of light energy to chemical energy stored in sugar

D. Support, Movement, Communication between cells

1. CYTOSKELETON - maintain cell shape, anchorage for organelles (cilia, flagella, centrosome)
2. EXTRACELLULAR MATRIX - binding of cells in tissues, surface protection, regulation
3. CELL JUNCTIONS - communication binding cells in tissues
4. CELL WALLS - maintain cell shape and skeletal support, surface proteins, binding in plants, fungi and protists

E. All organisms share functional features

1. Consist of cells with MEMBRANE
2. Have DNA as genetic material
3. Carry out METABOLISM (conversion of energy)

REVIEW QUESTIONS: P. 70 Connecting Concepts 1-3
P. 71 1-14, 15-18